

"COATING COMPOSITION FOR THERMOPLASTIC  
RESIN PARTICLES FOR FORMING FOAM CONTAINERS"

5        BACKGROUND OF THE INVENTION

1.    Field of the invention

      The present invention relates to thermoplastic resin particles for forming foam containers, such as cups, bowls, etc.; to a molded article, e.g. foam container made from the resin particles; to a coating composition for the thermoplastic resin particles; and to a method for improving the resistance to leakage of a foam container. More particularly, the present invention pertains to a coating composition for expandable or pre-expanded, i.e. "pre-puff", thermoplastic resin particles, e.g. polystyrene, used in molding containers for carrying liquids, e.g. coffee or foods containing oil and/or fat components such as precooked (instant noodles, soups, sauces, fried chicken) fat-containing foods, and the like.

2.    Background Art

      The manufacture of molded articles, e.g. containers, e.g. cups, bowls, made from expandable thermoplastic particles is well known. The most commonly used thermoplastic particles are expandable polystyrene particles, referred to as "EPS" particles. Typically, polystyrene beads are impregnated with a blowing agent, which boils below the softening point of the polystyrene and causes the impregnated beads to expand when they are heated. When the pre-expanded beads are heated in a mold cavity, they further expand to fill the cavity and fuse together to form a shaped article, e.g. containers, e.g. cups, bowls, etc.

5           The formation of molded articles from  
impregnated polystyrene beads is generally done in  
two steps. First, the impregnated polystyrene beads  
are pre-expanded to a density of from about 2 to 12  
pounds per cubic foot. The pre-expanded beads are  
10 typically called "pre-puff". This first step, i.e.  
the pre-expansion step, is conventionally carried  
out by heating the impregnated beads using any  
conventional heating medium such as steam, hot air,  
hot water, or radiant heat. Second, the pre-  
15 expanded beads ("pre-puff") are heated in a closed  
mold to further expand the pre-expanded beads to  
form a fused article having the shape of the mold.  
This latter step is generally referred to as  
molding.

20           The expandable polystyrene particles used to  
make foam containers are generally prepared by an  
aqueous suspension polymerization process, which  
results in beads that can be screened to relatively  
precise bead sizes. Typically, bead diameters are  
25 within the range of from about 0.008 to about 0.02  
inch. Occasionally, cups are made from particles  
having bead diameters as much as 0.03 inches.

          In spite of careful bead size control, one  
problem, which continues to plague the container,  
30 industry is that after a period of time the EPS  
containers have a tendency to leak coffee or to leak  
the oil and/or fat components in food substances  
carried by the containers. That is, the coffee or  
the oil and/or fat permeate around the fused  
35 polystyrene beads and through the wall of the  
container. With regard to the oil and/or fat

5 components, a stain generally forms on the outer surface of the container.

Several approaches have evolved over the years directed toward the reduction of leakage in containers for retaining liquids and/or pre-cooked  
10 foods.

Amberg et al., U.S. Patent 4,036,675 discloses a container made from foamed polystyrene, which is lined on one or both sides with unoriented polyolefin film, preferably polypropylene. The film  
15 is secured to the foamed plastic base material using a vinylic polymer or polyamide resin as a heat-sensitive adhesive. The film is coated with a wet adhesive and dried before laminating the film to the foam material.

20 Sonnenberg U.S. Patent Nos. 4,703,065 and 4,720,429 disclose thermoplastic polymer foam cups for retaining coffee that are molded from thermoplastic polymer particles whose surfaces are coated with a fluorosurfactant before molding.

25 Sonnenberg U.S. Patent No. 4,785,022 discloses a method for enhancing the coffee retention of molded foam cups. The method involves coating the expandable polystyrene particles with various rubber polymers and copolymers, e.g. polybutene,  
30 polyisobutylene, isobutylene-butene copolymer and butene-ethylene copolymer.

Arch, et al. U.S. Patent No. 4,798,749 and U.S. Patent No. 4,840,759 overcome the problem of coffee leakage by replacing conventional blowing agents  
35 such as butanes, n-pentane, hexanes, and the

5 halogenated hydrocarbons with isopentane in the expandable styrene polymer particles.

Ikeda, et al., U.S. Patent No. 4,698,367 discloses expandable thermoplastic resin particles composed of a fluorinated vinyl polymer and a hydrophilic vinyl polymer that covers or is included on the surface or in the surface layer of the expandable thermoplastic particle. These resin particles are useful for producing package containers for oily or fatty foods.

15 Sakoda et al., U.S. Patent No. 6,277,491 B1 discloses coating the surface of the resin beads or incorporating resin beads with a fluorine-containing block copolymer comprising a fluorine-containing vinyl-type polymer segment derived from a fluorine-containing vinyl-type monomer and a lipophilic vinyl-type polymer segment derived from a lipophilic vinyl-type monomer.

Suzuki et al., U.S. Patent No. 4,206,249 discloses a process for producing a paper container having high impermeability to liquid which comprises spray coating a polymerizable solution containing a pre-polymer onto a wall surface of a paper container and irradiating the coated wall with ultraviolet light to effect the setting of the pre-polymer on the wall surface of the container. This forms a coating, which is impermeable to liquids, such as water, milk, soft drinks, oils, etc.

Breining, et al., U.S. Patent No. 6,416,829 B2 discloses a heat insulating paper cup where the body member is coated on its outside surface with a foamed low density polyethylene, and on its inside

5 surface with an unfoamed modified low density  
polyethylene.

Japan Unexamined Patent Publication

JP2002338725A (Kaneka Corporation) discloses the use  
of a volatile foaming agent containing 30 to 60% by  
10 weight based on the foaming agent of isopentane.

The expandable polystyrene resin particles are  
covered with zinc stearate ranging between 0.2 to  
0.5 parts by weight based on 100 parts by weight of  
resin particle. The amount of foaming agent ranges  
15 from 0 to 5.5% by weight of the resin particles.

None of the thermoplastic resin particles of the  
prior art for making foam containers are coated or  
covered with a liquid polyethylene glycol and then  
with one or more components selected from the group  
20 consisting of polyolefin wax, e.g. polyethylene wax;  
a metal salt of higher fatty acids, e.g. zinc  
stearate; polyethylene glycol; and a fatty bisamide  
or fatty amide, e.g. ethylene bis-stearamide, for  
reducing or eliminating the penetration of liquid  
25 and/or oil and/or fat components of food items such  
as coffee, noodles, soups, sauces, stews, meats, and  
the like through the foam containers.

#### SUMMARY OF THE INVENTION

The invention meets the above need. The  
30 invention particularly relates to expandable  
thermoplastic particles, preferably polystyrene  
particles, for making molded articles, e.g. foam  
containers, e.g. bowls, cups, etc., which containers  
adequately retain oils and flavorings in food items  
35 such as instant noodles, etc., and liquids such as

5 hot coffee or hot water added to food items such as instant soups or noodles, stews, meats or the like.

Expandable or pre-expanded (sometimes referred to as "pre-puff") thermoplastic particles are coated or covered with a coating composition. The resultant  
10 containers are less pervious to leakage and/or stains caused by liquids and/or oily and fatty foods.

The coating composition essentially comprises two parts, 1) a liquid part and 2) a powder or solid  
15 part. The liquid part comprises a) greater than about 0.01% by weight, based on the weight of the particles, of polyethylene glycol having an average molecular weight ranging from about 200 to about 800 (PEG 200- PEG 800), and the solid part comprises  
20 components selected from the group consisting of: b) greater than about 0.01% by weight, based on the weight of the particles, of polyolefin wax; c) greater than about 0.01%, based on the weight of the particles, of a metal salt of higher fatty acids; d)  
25 greater than about 0.01%, based on the weight of the particles, of polyethylene glycol having an average molecular weight ranging from 900 to about 10,000 (PEG 900- PEG 10,000), and e) greater than about 0.01%, based on the weight of the particles, of a  
30 fatty bisamide or fatty amide, e.g. ethylene bis-stearamide, and combinations of b) through e).

For expandable particles, it is preferable to use component a) and one or more of components b) through e). For pre-expanded or "pre-puff"  
35 particles, component a) is optional, and one or more of components b) through e) are used.

5           A preferred embodiment is a coating composition comprising a) about 0.30% by weight of polyethylene glycol having an average molecular weight of 400 (PEG 400 in liquid form); b) about 0.40% by weight of polyolefin wax, preferably polyethylene wax, and  
10       c) about 0.105% by weight of a metal salt of higher fatty acid, preferably zinc stearate.

          Preferably, expandable thermoplastic particles are first coated with the liquid polyethylene glycol and then coated with the solid components of the  
15       coating composition of the invention. The solid components preferably are mixed or blended together and then mixed or blended with the thermoplastic particles. For pre-expanded particles, as stated hereinabove, the use of the liquid polyethylene  
20       glycol is optional. The solid components preferably are mixed or blended together and then mixed or blended with the thermoplastic particles.

          The invention also relates to a method for improving the resistance to leakage of molded  
25       articles, e.g. foam containers, e.g. cups, bowls, etc. made from thermoplastic resin particles. The method involves, preferably for expandable particles, first applying component a) to the particles and then applying one or more of the solid  
30       components of the coating composition to the expandable particles. For pre-expanded particles, the method involves, optionally applying component a) to the particles, and applying one or more of the solid components of the coating composition to the  
35       pre-expanded particles.

5           It is therefore an object of the present  
invention to provide molded articles, e.g. foam  
containers which exhibit improved resistance to  
leakage and therefore improved resistance to stain  
at least on the outer surface of the containers, and  
10       which exhibit improved mechanical properties, such  
as improved rim strength.

          It is a further object of the present invention  
to provide a coating composition for thermoplastic  
particles used to form foam containers that are  
15       suitable for retaining oily or fatty food items,  
such as noodles, soups, sauces, stews, meats, and  
the like, or for retaining liquids such as hot  
coffee or hot water for instant noodles, soups,  
stews, etc., and which foam container has at least  
20       improved ATF properties and/or improved rim strength  
properties.

          A still further object of the present invention  
is to provide expandable or pre-expanded  
thermoplastic particles comprising a coating  
25       composition, which increases the integrity of foam  
articles made from the particles.

          And yet a still further object of the present  
invention is to provide a method for improving the  
resistance to leakage of a foam container by  
30       providing a coating composition for coating  
thermoplastic resin particles used to form the foam  
container.

          These and other object of the present invention  
will be better appreciated and understood by those  
35       skilled in the art from the following description  
and appended claims.



5        DETAILED DESCRIPTION OF THE INVENTION

          As used herein, the term "coat" means to  
contact with a coating composition so as to place a  
substantial portion of the components of the coating  
composition of the invention on or near the surface  
10        or surfaces of the resin particles being contacted.

          As used herein, the term "cover" means  
principally in the form in which the coating  
composition adheres in layers on the surface of the  
resin particles.

15        The coating composition of the invention  
essentially comprises two parts, 1) a liquid part  
and 2) a powder or solid part. The liquid part  
comprises a) greater than about 0.01% by weight,  
based on the weight of the particles, of  
20        polyethylene glycol having an average molecular  
weight ranging from about 200 to about 800 (PEG 200-  
PEG 800). Preferably, the weight percent of the  
liquid polyethylene glycol is 0.01% by weight to  
about 0.80% by weight, based on the weight of the  
25        particles. The solid part of the coating  
composition of the invention comprises components  
selected from the group consisting of: b) greater  
than about 0.01% and, preferably 0.01% to about 1.0%  
by weight, based on the weight of the particles, of  
30        polyolefin wax, preferably polyethylene wax; c)  
greater than about 0.01%, and preferably 0.01% to  
about 0.60% by weight, based on the weight of the  
particles, of a metal salt of higher fatty acid,  
preferably zinc stearate; d) greater than about  
35        0.01%, and preferably 0.01% to about 0.80% by  
weight, based on the weight of the particles, of

5 polyethylene glycol having an average molecular weight ranging from 900 to about 10,000 (PEG 900-PEG 10,000), and e) greater than about 0.01%, and preferably 0.01% to 1.0% by weight, based on the weight of the particles, of a fatty amide or fatty  
10 bisamide, e.g. ethylene bis-stearamide, and combinations of components b) through e).

For expandable beads, i.e. dense beads, the coating composition preferably comprises component a) and at least one or more of components b) through  
15 e) in combination with component a). For example, the combinations may be comprised of components a) and b); or components a) and c); or components a) and d); or components a) and e); or components a), b), and c); or components a), c), and d); or  
20 components a), b), and d); or components a), b), and e); or components a), c), and e); or components a), d), and e); or components a), b), c), and d); or components a), b), c), and e); or components a), c), d), and e); or  
25 components a), b), c), d), and e).

For pre-expanded particles or "pre-puff" particles, the liquid part is not necessary but in some instances may be preferred, for reasons discussed herein below. For the pre-expanded  
30 particles, the solid part of the coating composition will comprise at least of one or more of components b) through e), which may be in combinations similar to those listed in the preceding paragraph for expandable particles.

35 Any of components a) through e) must be present in an amount greater than or equal to 0.01% by

5 weight, if used alone. If component b) is used it  
should be present in an amount that is at least  
0.01% to about 1.0% by weight, based on the weight  
of the particles. If component d) is used it should  
be present in an amount that is at least 0.01% to  
10 about 0.8% by weight, based on the weight of the  
particles. If components b) and d) are used, then  
preferably both components b) and d) would be  
present to give a combined weight percent of about  
0.01 to about 1.8% by weight based on the weight of  
15 the particles. This is an example of a desirable  
total weight percentage for a combination of  
components b) and d). Desirable total weight  
percentages for other combinations of components b)  
through e) will be apparent to those skilled in the  
20 art.

The expandable, and therefore, the pre-expanded  
thermoplastic particles can be made from any  
suitable thermoplastic homopolymer or copolymer.  
Particularly suitable for use are homopolymers  
25 derived from vinyl aromatic monomers including  
styrene, isopropylstyrene, alpha-methylstyrene,  
nuclear methylstyrenes, chlorostyrene, tert-  
butylstyrene, and the like, as well as copolymers  
prepared by the copolymerization of at least one  
30 vinyl aromatic monomer with monomers such as  
divinylbenzene, butadiene, alkyl methacrylates,  
alkyl acrylates, acrylonitrile, and maleic  
anhydride, wherein the vinyl aromatic monomer is  
present in at least 50% by weight of the copolymer.  
35 Styrenic polymers are preferred, particularly  
polystyrene. However, other suitable polymers may

5       be used, such as polyolefin, e.g. polyethylene,  
polypropylene, and mixtures thereof.

      In the embodiments herein, the expandable  
thermoplastic particles are expandable polystyrene  
(EPS) particles. These particles can be in the form  
10      of beads, granules, or other particles convenient  
for the expansion and molding operations. Particles  
polymerized in an aqueous suspension process are  
essentially spherical and are preferred for molding  
or forming the foam container of the invention.  
15      These particles are typically screened so that their  
size ranges from about 0.008 to about 0.02 inch, and  
in some instances ranges from about 0.008 to about  
0.03 inch.

      The thermoplastic particles are impregnated  
20      using any conventional method with a suitable  
blowing agent. For example, the impregnation can be  
achieved by adding the blowing agent to the aqueous  
suspension during the polymerization of the polymer,  
or alternatively by re-suspending the polymer  
25      particles in an aqueous medium and then  
incorporating the blowing agent as taught in U.S.  
Patent No. 2,983,692 to D. Alelio. Any gaseous  
material or material which will produce gases on  
heating can be used as the blowing agent.

30      In the present invention, the blowing agent can  
be aliphatic hydrocarbons, such as acetone, methyl  
acetate, butane, n-pentane, cyclopentane,  
isopentane, isobutene, neopentane, and mixtures  
thereof. A preferred blowing agent is normal  
35      pentane and mixtures of pentanes i.e. normal  
pentane, isopentane and/or cyclopentane. Other

5       blowing agents that can be used in the invention are  
halogenated hydrocarbons, e.g. HFC's, CFC's and  
HCFC'S, and mixtures thereof. For the expandable  
particles of the invention, any of the preceding  
blowing agents may also be used in combination with  
10       carbon dioxide, air, nitrogen, and water.

      The blowing agent level of the polymer  
particles generally will be less than 10.0 weight  
percent, preferably, less than 9.0 weight percent,  
and most preferably will range from between about  
15       3.0 weight percent to about 6.0 weight percent based  
on the weight of the thermoplastic resin  
composition.

      Alternatively, water can be blended with the  
aliphatic hydrocarbons blowing agents or water can  
20       be used as the sole blowing agent as taught in U.S.  
Patent Nos. 6,127,439; 6,160,027; and 6,242,540  
assigned to NOVA Chemicals (International) S.A. In  
these patents, water-retaining agents are used. The  
weight percentage of water for use as the blowing  
25       agent can range from 1 to 20%. U.S. Patent Nos.  
6,127,439, 6,160,027 and 6,242,540 in their entirety  
are incorporated herein by reference.

      The impregnated thermoplastic particles can be  
foamed cellular polymer particles as taught in Arch  
30       et al. U.S. Patent Application Serial No. 10/021,716  
assigned to NOVA Chemicals Inc. The foamed cellular  
particles are preferably polystyrene that are pre-  
expanded to a density of from about 12.5 to about  
34.3 pounds per cubic foot, and which contain a  
35       volatile blowing agent level that is less than 6.0  
wt %, preferably ranging from about 2.0 wt % to

5        about 5.0 wt %, and more preferably ranging from  
about 2.5 wt % to about 3.5 wt %, based on the  
weight of the polymer.

10        The impregnated expandable thermoplastic  
particles are generally pre-expanded to a density of  
from about 2 to about 12 pounds per cubic foot prior  
to molding. The pre-expansion step is carried out  
conventionally by heating the impregnated beads via  
any conventional heating medium, e.g. steam, hot  
air, hot water, or radiant heat. One generally  
15        accepted method for accomplishing the pre-expansion  
of impregnated thermoplastic particles is taught in  
U.S. Patent No. 3,023,175 to Rodman.

20        The pre-expanded beads are heated in a closed  
mold to further expand the pre-expanded particles to  
form a foam article, i.e. container.

25        In an embodiment of the invention, expandable,  
i.e. impregnated thermoplastic particles are covered  
or coated with component a), the liquid polyethylene  
glycol, and then covered or coated with the solid  
components of the coating composition of the  
invention prior to the particles being subjected to  
pre-expansion and molding steps. Any conventional  
method of coating or covering particles may be  
utilized in the invention.

30        In a further embodiment of the invention, the  
expandable particles are pre-expanded and the pre-  
expanded thermoplastic particles are coated or  
covered with the liquid polyethylene glycol and then  
coated or covered with the solid components of the  
coating composition of the invention prior to the  
35        particles being subjected to the molding step.

5           It is to be understood that in some instances  
the pre-expanded particles do not need to be coated  
with the liquid polyethylene glycol in that the pre-  
expanded particles generally have a rougher surface  
10       of the solid components of the coating composition  
compared to expandable particles that generally have  
a smooth surface finish and less surface area.  
However, it has been found by the inventors that the  
liquid polyethylene glycol tends to lessen the  
15       static electricity generally associated with pre-  
puff particles, especially during the conveyance of  
these particles via air flow from one piece of plant  
equipment to another piece of plant equipment.  
Thus, the application of the liquid polyethylene  
20       glycol on pre-expanded or pre-puff particles may be  
desirable in some instances.

          The liquid polyethylene glycol and the solid  
components of the coating composition cover or coat  
or can be included on the surfaces of the expandable  
25       thermoplastic resin particles. As stated herein  
above, the term "cover" means principally in the  
form in which the coating composition adheres in  
layers on the surface of the resin particles. This  
can be achieved by first contacting the resin  
30       particles with the liquid polyethylene glycol and  
then sufficiently mixing the resin particles with  
the solid components of the coating composition in a  
mixer, such as a drum blender, ribbon blender, V  
blender, Henschel mixer, Ledage mixer, a high  
35       intensity mixer, a low intensity blender, and the  
like.

5           The solid components of the coating composition preferably are in powder form. However, the powder form may be made into liquid form by dissolving the powder in solvent or dispersing the powder in water.

10           Preferably, the thermoplastic particles are contacted first with the liquid polyethylene glycol and then contacted with one or more of the solid components of the coating composition of the invention, as discussed herein above. The solid components preferably are mixed or blended together and then blended or mixed with the thermoplastic particles.

15           The polyolefin wax of component b) is selected from the group consisting of polyethylene wax and polypropylene wax, and preferably is polyethylene wax. The polyolefin wax has an average molecular weight of about 650 to about 30,000; preferably is in powder form; and has a particle size ranging from about 1 to about 140 microns in diameter, preferably, about 6 microns.

25           The metal salt of higher fatty acids used as component c) in the coating composition is selected from the group consisting of zinc, magnesium, calcium or aluminum salts of stearic, lauric or myristic acid, of which zinc stearate is preferable.

30           For a preferred embodiment the coating composition of the invention comprises: component a), polyethylene glycol, in an amount of about 0.30% by weight, based on the weight of the particles, and having an average molecular weight of about 400 (PEG 400 in liquid form); component b), polyolefin wax, preferably polyethylene wax, in an amount of about

35



5        0.40% by weight, based on the weight of the  
particles, and having a particle size of about 6  
microns and an average molecular weight of 1,000;  
and component c), a metal salt of higher fatty  
acids, preferably zinc stearate, in an amount of  
10       about 0.105% by weight, based on the weight of the  
particles.

      In applying the coating composition to the  
particles, as stated herein above, it is preferable  
to first cover the resin particles with liquid  
15       polyethylene glycol, which is believed to modify the  
surface tension, i.e. make the surface more  
hydrophilic, and which is an adhering agent for the  
coating composition, and then to cover the resin  
particles with the solid components of the coating  
20       composition.

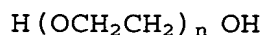
      Preferably, the liquid polyethylene glycol has  
an average molecular weight of about 200 to about  
800 (PEG 200-PEG 800), and preferably, has an  
average molecular weight ranging from about 300 to  
25       about 600. In general, the number appearing after  
the designation "PEG" (polyethylene glycol)  
indicates the average molecular weight, e.g. PEG 200  
represents polyethylene glycol with an average  
molecular weight of about 200, etc.

30       The amount of liquid polyethylene glycol is  
greater than 0.01 and preferably is 0.01% to about  
0.80% by weight, based on the weight of the  
particles, and preferably ranges from about 0.05 to  
about 0.50% by weight, based on the weight of the  
35       particles.

5           The coating composition covers the  
thermoplastic resin particles preferably in an  
amount of 0.005 to 2.0% by weight based on the  
weight of the particles, and more preferably 0.01 to  
1.0% by weight, based on the weight of the  
10 thermoplastic resin particles. If the coverage of  
the coating composition is less than 0.005% by  
weight, the effect of the prevention of leakage of  
the liquid or fatty/oil components of the container  
is generally insufficient, and if the coverage  
15 exceeds 2.0% by weight, there may be a tendency to  
increase the amount of lumping in the pre-expansion  
of the particles or there may be a tendency to  
retard the fusing together of the thermoplastic  
particles in the molding process.

20           A method of the invention relates to the  
expandable and optionally pre-expanded thermoplastic  
particles first being coated with the component a),  
i.e. the liquid polyethylene glycol e.g. PEG 400,  
component, and then blending the particles with a  
25 mixture of the solid coating composition. If the  
coating composition is applied to expandable  
thermoplastic particles, these particles are then  
pre-expanded, and fed to the mold. If the coating  
composition is applied to pre-expanded thermoplastic  
30 particles, these particles are then fed to the mold.

Polyethylene glycols suitable for use in the  
coating composition of the invention are represented  
by the following general formula:



5 Polyethylene glycols having the above general formula are commercially available from BASF under the trademark PLURACOL®.

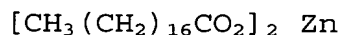
Polyethylene waxes suitable for use in the coating composition of the invention are represented by the following general formula:



Polyethylene waxes having the above general formula are commercially available from Baker Petrolite under the trademark PETROLITE®.

15 Preferably, polyethylene waxes having an average molecular weight ranging from about 650 to about 30,000 and a particle size ranging between 1 micron and 140 microns are used in the coating composition of the invention.

20 Zinc stearates suitable for use in the coating composition of the invention are represented by the following general formula:



25 Zinc stearates having the above general formula are commercially available from Ferro under the trademark SYNPRO®.

Ethylene bis-stearamides suitable for use in the coating composition of the invention are represented by the following general formula:



30 Ethylene bis-stearamide having the above general formula are commercially available from the Crompton Corporation under the trademark KEMAMIDE® W-40.

35 In addition to substantially coating or covering the thermoplastic resin particles with the

5       coating composition of the invention, an alternate approach is to add the coating composition at the time of impregnating the thermoplastic resin particles with a blowing agent to retain the coating composition in the surface layer of the resin beads.

10       Preferably, the entire surface of the thermoplastic resin particles is to be coated or covered with a thin film or layer of the coating composition. However, it may be adequate for the purposes of the invention if only a portion of the  
15       surfaces of the particles is coated or covered with the coating composition of the invention.

      The foam container may be a polystyrene cup that may be fabricated by a conventional cup-forming machine that has an inner shell and an outer shell.  
20       An example of this type of machine is MODEL 6-VLC-125 machine made by Autonational B.V. Impregnated thermoplastic particles are either aged or un-aged, are coated with the coating composition, are pre-expanded, and are then fed to a conventional cup-  
25       forming machine.

      The cup fabrication rate for a single machine (6 molds) producing 10-ounce cups or 16-ounce cups can range from about 30 to 100 cups per minute. Several machines can be used to increase the  
30       production rate.

      It has been found that the coating composition also tends to improve the rim strength of the container, which in effect, improves the overall strength of the container. The rim strength is a  
35       measure of the force required (in kilograms) to

5        cause the rim to crumble a one-fourth inch  
displacement from the opened edge of the container.

      The invention is further illustrated, but not  
limited by, the following examples.

### Examples

#### Examples 1-4

10        For Examples 1-4, expandable polystyrene beads  
(NOVA Chemical F271TU or F-271T) were first blended  
with component a) liquid polyethylene glycol 400  
(PEG 400) in a drum mixer. These PEG coated beads  
15        were then coated with the coating composition  
comprising the following components: polyethylene  
glycol 8000 (PEG 8000); and/or polyethylene wax (PE  
1000 T6); and/or zinc stearate (ZnS) in the amounts  
shown in Tables 1-4. The designation PE 1000 T6 for  
20        the polyethylene wax indicates that the polyethylene  
wax has an average molecular weight of about 1000  
and a particle size of about 6 microns. This  
polyethylene wax, PE 1000 T6 is available from the  
Baker Petrolite Corporation under the trademark  
25        PETROLITE®.

#### Example 1

      Five samples (I-V) were prepared by the  
following procedure:

30        3.8 pounds of impregnated NOVA Chemicals F271TU  
(expandable polystyrene) cup beads, ranging from  
0.010 to 0.020 inch in diameter and containing 5.6%  
by weight, based on the weight of the particles, of  
mixed pentane (n-pentane and isopentane in the ratio  
of 90:10), and for samples (II-V), liquid PEG 400 in  
35        the amounts shown in Table 1 were stir blended in a  
drum container for 5 minutes. The components of the

5 solid part of the coating composition in the amounts  
shown in Table 1 were added to the mixture and the  
contents were further blended for another 5 minutes.

The impregnated, coated beads were pre-expanded  
in an 11-gallon Rodman Steam pre-expander (Artisan  
10 Industries Inc.) at atmospheric pressure. The pre-  
expansion was operated batch wise with a target pre-  
puff density of 4.0 pounds per cubic foot (pcf).  
The newly prepared pre-puff was air dried for 5  
minutes to remove the moisture and was allowed to  
15 age for about 4 hours before molding.

Ten-ounce cups were molded using the aforesaid  
Autonational Cup Machine Model 6VLC-125 (standard  
molding conditions) and using the pre-expanded beads  
with the densities indicated in Table 1. The steam  
20 header pressure was 100 pounds per square inch (psi)  
and the total cycle time was about 12 seconds. The  
molded cups were allowed to age overnight before  
testing.

Four cups for each sample (I-V) were tested by  
25 the following method: 1) Since the upper portion of  
the cup is the most vulnerable area for leakage,  
testing was done in this area. A circular piece of  
molded EPS material was placed down into each cup so  
that the upper 20% to 30% of the cup was made  
30 available for testing. 2) 15 grams of oil-fried  
pasta were crushed and spread evenly on the circular  
piece of molded EPS material so that the pasta  
occupied the upper 20 to 30% of the cup. 3) 3 grams  
of red pepper powder were spread evenly onto the  
35 crushed pasta. 4) Each cup was tightly sealed with  
an adhesive label and plastic stretch film and

placed in an oven at a temperature of 149°F (65°C).  
5) Each sample was checked for stains first every hour during a 7 hour period and then once every 8 hours until failure for a maximum of 3 days.

The average time to failure (ATF) for each cup group sampling was calculated by adding the time to failure for each container and dividing the total time by the number of containers that were tested. The maximum ATF value of 72 hours represents that none of the cups for the cup group sampling exhibited any stain or leakage. The minimum ATF value of 1 hour represents that all of the cups in the cup group sampling failed within the first 1 hour.

Each cup in each cup group sampling (10 cups in each of these group samplings) was tested for rim strength (force applied on the cup rim at ¼ inch displacement) and the average force was recorded.

The results for the stain resistance and rim strength are shown in Table 1.

Table 1

Sample	I (Control)	II	III	IV	V
PEG 400 (g)	---	5.17	3.50	3.50	0.90
PE 1000 T6 (g)	---	6.89	9.00	12.00	18.00
PEG 8000 (g)	---	---	---	---	---
ZnS (g)	1.80	1.80	1.80	---	---
Density (pcf)	3.96	3.95	4.08	4.11	4.15
Rim Strength (kg)	0.286	0.316	0.330	0.312	0.327
ATF (hour)	1.5	72	25	37.5	14

As Table 1 indicates, cups formed with impregnated polystyrene particles that were coated or covered with the coating composition of the invention (Samples II-V) had improved rim strength

5 and improved ATF compared to the control cups  
(Sample I) that were formed with particles coated  
only with zinc stearate.

Example 2

10 The procedure of Example 1 was repeated using  
the amounts and components shown in Table 2.

Table 2

Sample	I (Control)	VI	VII	VIII
PEG 400 (g)	---	0.60	3.50	3.45
PE 1000 T6(g)	---	---	---	---
PEG 8000 (g)	---	---	---	5.17
ZnS (g)	1.80	1.80	1.80	1.80
Density (pcf)	3.96	3.95	4.05	3.84
Rim Strength (kg)	0.286	0.298	0.323	0.307
ATF (hour)	1.5	1.0	3	27

15 As Table 2 indicates, cups (Samples VI-VIII)  
formed with impregnated polystyrene particles coated  
or covered with the coating composition of the  
invention had improved rim strength and in general  
improved ATF compared to the control cups (Sample I)  
that were formed with particles coated solely with  
zinc stearate.

20 Example 3

The procedure of Example 1 was repeated except  
that the expandable polystyrene beads were  
substituted with beads containing 5.6% by weight,  
based on the weight of the beads, of normal pentane  
25 as the sole blowing agent.



Table 3

Sample	IX (Control)	X	XI	XII	XIII
PEG 400 (g)	---	5.17	3.50	3.50	3.45
PE 1000 T6 (g)	---	6.89	---	12.00	8.62
PEG 8000 (g)	---	---	---	---	---
ZnS (g)	1.80	1.80	1.80	---	1.80
Density (pcf)	3.81	4.06	3.96	4.31	4.06
Rim Strength (kg)	0.306	0.328	0.316	0.328	0.336
ATF (hour)	1.5	28	2	23	15

As Table 3 indicates, cups formed with polystyrene particles impregnated with 5.6% by weight, based on the weight of the particles, of normal pentane as the sole blowing agent and that were coated or covered with the coating composition of the invention (Samples X through XIII) had improved rim strength and improved ATF compared to the control cups (Sample IX) that were coated solely with zinc stearate.

#### Example 4

The procedure of Example 3 was repeated except that the expandable polystyrene beads were substituted with beads containing 5.65% by weight, based on the weight of beads, of normal pentane as the sole blowing agent and that were pre-lubricated with 0.0225% by weight silicon oil. The beads were coated or covered with the components in the amounts shown in Table 4.

Table 4

Sample	XIV (Control)	XV
PEG 400 (g)	---	5.17
PE 1000 T6 (g)	---	6.89
PEG 8000 (g)	---	---
ZnS (g)	1.80	1.80
Density (pcf)	3.98	4.13
Rim Strength (kg)	0.309	0.330
ATF (hour)	1.5	19

5           As Table 4 indicates, the cups formed with the  
expandable polystyrene particles having 5.6% by  
weight, based on the weight of the beads, of normal  
pentane as the sole blowing agent and that were  
coated or covered with the coating composition of  
10 the invention (Sample XV) had improved ATF and  
improved rim strength compared to the control cups  
(Sample XIV) that were formed with beads coated only  
with zinc stearate.

Example 5

15           3.8 pounds of impregnated NOVA Chemicals F271TU  
(expandable polystyrene) cup beads, ranging from  
0.010 to 0.020 inch in diameter and containing 5.6%  
by weight, based on the weight of the beads, of  
normal pentane and 1.80 grams of zinc stearate were  
20 stir blended in a drum container for 5 minutes. The  
impregnated zinc stearate coated beads were pre-  
expanded in an 11-gallon Rodman Steam pre-expander  
(Artisan Industries Inc.) at atmospheric pressure.  
The pre-expansion was operated batch wise with a  
25 target pre-puff density of 4.0 pounds per cubic foot  
(pcf). The newly prepared pre-puff was air dried  
for 5 minutes to remove the moisture and was allowed  
to age for about 4 hours. 0.65 pounds of the pre-  
puff beads were stir blended with 2.95 grams  
30 polyethylene wax (PE 1000 T6) for 5 minutes. The  
coated pre-puff beads were molded using Autonational  
Cup Machine Model 6VLC-125 (standard molding  
conditions). The cup molding, the stain testing,  
and the rim strength testing were done similar to  
35 that for Examples 1-4. The formulations and test  
results are shown in Table 5.

Table 5

Sample	XVI (Control)	XVII
Bead Lubrication		
Bead Weight (lb.)	3.80	3.80
Zinc Stearate (g)	1.80	1.80
Pre-Puff Lubrication		---
Pre-Puff Weight (lb)	0.65	0.65
PE 1000 T6 (g)	---	2.95
Pre-Puff Density (pcf)	3.88	3.88
Rim Strength (kg)	0.301	0.301
ATF (hour)	1.5	39

Example 5 shows that cups (Sample XVII) formed with particles that were coated or covered with the coating composition of the invention had improved ATF compared to the control cups (Sample XVI) formed with particles covered or coated only with zinc stearate.

#### Example 6

Expandable polystyrene beads (NOVA Chemical F271TU) were first blended with liquid polyethylene glycol 400 (PEG 400) in a Ross ribbon mini-blender 42N-1/4S (Charles Ross & Son Company, Hauppauge, New York). These PEG coated beads were then coated with a polyethylene wax in the amounts shown in Table 6 and selected from one of the following types of waxes: 1) PE 1000 T6, which is a polyethylene wax having an average molecular weight of about 1000 and a particle size of about 6 microns; 2) PE 850 T10, which is a polyethylene wax having an average molecular weight of about 850 and a particle size of about 10 microns; 3) PE 655 T10, which is a polyethylene wax having an average molecular weight of about 655 and a particle size of about 10 microns; and 4) PE 500 T60, which is a polyethylene wax having an average molecular weight of about 500 and a particle size of about 60 microns. Zinc

5        stearate (ZnS) was used on all samples in the  
amounts shown in Table 6. The polyethylene waxes  
are obtained from the Baker Petrolite Corporation  
under the trademark PETROLITE®.

10        Five samples (XVIII-XXII) were prepared by the  
following procedure:

8 pounds of the impregnated, expandable  
polystyrene cup beads, ranging from 0.010 to 0.020  
inch in diameter and containing 5.6% by weight,  
based on the weight of the particles, of normal  
15        pentane and liquid PEG 400 in the amounts shown in  
Table 6 were blended in the mini-blender for 10  
minutes. The components of the solid part of the  
coating composition in the amounts shown in Table 6  
were added to this mixture and the contents were  
20        further blended for another 10 minutes.

The impregnated, coated beads were pre-expanded  
in an 11-gallon Rodman Steam pre-expander (Artisan  
Industries Inc.) at atmospheric pressure. The pre-  
expansion was operated batch wise with a target pre-  
25        puff density of 4.0 - 4.5 pounds per cubic foot  
(pcf). The newly prepared pre-puff was air dried  
for 5 minutes to remove the moisture and was allowed  
to age for about 4 hours before molding.

30        Sixteen-ounce cups were molded using a Master  
Cup Machine M10 (Master Machine & Tool Co.,  
Mulberry, FL) under standard molding conditions. The  
pre-expanded beads had the densities indicated in  
Table 6. The steam header pressure was 100 pounds  
per square inch (psi) and the total cycle time was  
35        about 14.8 seconds. The molded cups were allowed to  
age overnight before testing.

5 Four cups for each sample (XVIII-XXII) were  
 tested by the following method: 1) In a method  
 similar to that set forth for Examples 1-4, oil  
 fried pre-shaped Nissin cup noodles, available in  
 the US market, were placed in each cup. 2) 3 grams  
 10 of red pepper powder were spread evenly onto the  
 noodle surface. 3) Each cup was tightly sealed with  
 an adhesive label and plastic stretch film, and  
 placed in the oven at a temperature of 149°F (65°C).  
 4) Each sample was checked for stains first every  
 15 hour during a 7 hour period and then once every 8  
 hours until failure for a total of 72 hours or 3  
 days.

The average time to failure (ATF) was  
 calculated similar to that set forth in Example 1.  
 20 The maximum ATF value of 72 hours represents that  
 none of the cups for the cup group sampling  
 exhibited any stain or leakage. The minimum ATF  
 value of 1 hour represents that all of the cups in  
 the cup group sampling failed within the first 1  
 25 hour.

The results for the stain resistance, in terms  
 of ATF, are shown in Table 6.

Table 6

Sample	XVIII (Control)	XIX	XX	XXI	XXII
F271TU (lb)	8.0	8.0	8.0	8.0	8.0
PEG 400 (g)	10.9	10.9	10.9	10.9	10.9
PE 1000 T6 (g)	-	14.5	-	-	-
PE 850 T10 (g)	-	-	14.5	-	-
PE 655 T10 (g)	-	-	-	14.5	-
PE 500 T60 (g)	-	-	-	-	14.5
ZnS (g)	3.8	3.8	3.8	3.8	3.8
Density (pcf)	4.07	4.39	4.36	4.50	4.36
ATF (hour)	1.8	41	23	28	30

5           As Table 6 indicates, cups formed with  
impregnated polystyrene particles that were coated  
or covered with the coating composition of the  
invention (Samples XIX-XXII) had improved ATF  
compared to the control cups (Sample XVIII) that  
10       were formed with particles coated only with zinc  
stearate.

Control Sample XVIII of Example 6 is compared  
to the samples of Examples 7, 8, and 9.

Example 7

15           The procedure of Example 6 was repeated for  
Example 7. The beads were coated or covered with  
the components in the amounts shown in Table 7.

Table 7

Sample	XVIII (Control)	XXIII
F271TU (lb)	8.0	8.0
PEG 400 (g)	--	3.63
PEG 8000 (g)	---	7.26
ZnS (g)	3.8	9.07
Density (pcf)	4.07	4.02
ATF (hour)	1.8	72

As Table 7 indicates, the cups formed with the  
20       expandable polystyrene particles having 5.6% by  
weight, based on the weight of the beads, of normal  
pentane as the sole blowing agent and that were  
coated with the coating composition of the invention  
(Sample XXIII) had improved ATF compared to the  
25       control cups (Sample XVIII) that were formed with  
beads coated only with zinc stearate.

Example 8

The procedure of Example 6 was repeated for  
Example 8 with the components in the amounts shown  
30       in Table 8. The coated beads were aged for 48 hours  
before pre-expansion.

Table 8

Sample	XVIII (Control)	XXIV
F271TU (lb)	8.0	8.0
PEG 400 (g)	---	10.9
PE 1000 T60 (g)	---	14.5
ZnS (g)	3.8	3.8
Density (pcf)	4.07	3.98
ATF (hour)	1.8	48

As Table 8 indicates, the cups formed with the expandable polystyrene particles having 5.6% by weight, based on the weight of the beads, of normal pentane as the sole blowing agent that were coated or covered with the coating composition of the invention (Sample XXIV) had improved ATF compared to the control cups (Sample XVIII) that were formed with beads coated solely with zinc stearate.

#### Example 9

The procedure of Example 7 was repeated. PEG 8000 was substituted with ethylene bis-stearamide powder (available from the Crompton Corporation under the trade mark KEMAMIDE® W-40). The beads were coated or covered with the components in the amounts shown in Table 9.

Table 9

Sample	XVIII (Control)	XXV
F271TU (lb)	8.0	8.0
PEG 400 (g)	---	10.8
KEMAMIDE® W-40 (g)	---	14.5
ZnS (g)	3.8	3.8
Density (pcf)	4.07	4.18
ATF (hour)	1.8	26

As Table 9 indicates, the cups formed with the expandable polystyrene particles having 5.6% by weight, based on the weight of the beads, of normal

5 pentane as the sole blowing agent, that were coated with the coating composition of the invention (Sample XXV) had improved ATF compared to the control cups (Sample XVIII) that were formed with beads coated solely with zinc stearate.

10 Example 10

Expandable polystyrene beads (NOVA Chemical F271TU) were first blended with liquid polyethylene glycol 400 (PEG 400) in a drum mixer. These PEG coated beads were then coated with polyethylene wax and zinc stearate (ZnS) in the amounts shown in 15 Table 10. The polyethylene wax had an average molecular weight of about 1000 and a particle size of about 6 microns. (PE 1000 T6 obtained from Baker Petrolite under the trademark Petrolite®.)

20 Two samples (XXVI-XXVII) were prepared by the following procedure:

3.8 pounds of impregnated NOVA Chemicals F271TU (expandable polystyrene) cup beads, ranging from 0.010 to 0.020 inch in diameter and containing 5.6% 25 by weight, based on the weight of the particles, of normal pentane.

For sample XXVII, liquid PEG 400 in the amount shown in Table 10 was stir blended with the particles in a drum container for 5 minutes. The 30 polyethylene wax (PE 1000 T6) and zinc stearate in the amounts shown in Table 10 were added to this mixture and the contents were further blended for another 5 minutes.

The impregnated, coated beads were pre-expanded 35 in an 11-gallon Rodman Steam pre-expander (Artisan Industries Inc.) at atmospheric pressure. The pre-



5 expansion was operated batch wise with a target pre-puff density of 4.0 pounds per cubic foot (pcf). The newly prepared pre-puff was air dried for 5 minutes to remove the moisture and was allowed to age for about 4 hours before molding.

10 Ten-ounce cups were molded using Autonational Cup Machine Model 6VLC-125 (standard molding conditions) and using the pre-expanded beads having the densities indicated in Table 10. The steam header pressure was 100 pounds per square inch (psi) and the total cycle time was about 12 seconds. The  
15 molded cups were allowed to age overnight before testing.

Ten cups for each sample (XXVI-XXVII) were tested by the following method: Coffee at 170°F was  
20 poured into each cup and the side walls and bottom of each cup containing coffee were observed for coffee stains or leakage every 15 minutes for the first 2 hours, every one hour from 2 to 6 hours, and then every 8 hours until failure or for a maximum of  
25 6 days.

The average time to failure (ATF) was calculated similar to that set forth in Example 1. The maximum ATF value of 144 hours represents that none of the cups for the cup group sampling  
30 exhibited any stain or leakage. The minimum ATF value of 0.25 hour represents that all of the cups in the cup group sampling failed within the first 15 minutes.

The results for coffee resistance are shown in  
35 Table 10.

Table 10

Sample	XXVI (Control)	XXVII
F271TU (lb)	3.8	3.8
PEG 400 (g)	-	5.17
PE 1000 T6 (g)	-	6.89
ZnS (g)	-	1.81
Density (pcf)	3.88	3.96
ATF (hour)	2.9	144

As Table 10 indicates, cups formed with impregnated polystyrene particles that were coated or covered with the coating composition of the invention (Sample XXVII) had improved ATF compared to the control cups (Sample XXVI) that were formed with particles coated solely with zinc stearate.

The impregnated thermoplastic particles coated or covered with the coating composition of the invention can be used to form foam containers that hold pre-packaged foods, e.g. instant noodles and/or soups, stews, meats, etc. that are sold on the shelves in the grocery store.

While the present invention has been set forth in terms of specific embodiments thereof, it will be understood in view of the instant disclosure that numerous variations upon the invention are now enabled yet reside within the scope of the invention. For example, even though foam containers are specifically described herein, it is to be understood, that the coating composition for thermoplastic resin particles may be used to form other types of molded articles. Accordingly, the invention is to be broadly construed and limited only by the scope and spirit of the claims now appended hereto.